



NEW INFORMATION ON *MEGARAPTOR NAMUNHUIQUII*
(THEROPODA: TETANURAE), PATAGONIA:
CONSIDERATIONS ON PALEOECOLOGICAL ASPECTS ¹
(With 6 figures)

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ABSTRACT: *Megaraptor* is a giant theropod included as a possible Coelurosauria. Its big claw was originally assigned to the digit II of the pes. In the last year, the discovery of complete manus bones of a *Megaraptor* allowed the knowledge of new morphological characters and, therefore, new interpretations on phylogenetic relationships. As a result, *Megaraptor* was proposed to be a basal tetanuran sharing characteristics with charcarodontosaurids and spinosaurids. In general, manus of basal tetanurans are quite unknown as they commonly lack phalanges, carpals or even the complete manus, being the information on them limited. So that, the hand elements of *Megaraptor* here studied represents an important material not only for furnishing new morphological data but also for the understanding of its behavior.

Key words: *Megaraptor*. Theropoda. Portezuelo Formation. Upper Cretaceous. Patagônia.

RESUMO: Nova informação sobre *Megaraptor namunhuaiquii* (Theropoda: Tetanurae), Patagonia: considerações sobre aspectos paleoecológicos.

Megaraptor é um terópoda gigante considerado como um possível Coelurosauria. Sua enorme garra foi originalmente atribuída ao dígito II do pé. No último ano, a descoberta de ossos atribuídos a uma mão completa de *Megaraptor* permitiu o conhecimento de novos caracteres morfológicos e, portanto, novas interpretações sobre as relações filogenéticas. Como resultado, *Megaraptor* foi considerado como um tetanuro basal compartilhando características com os carcarodontossaurídeos e os espinossaurídeos. Em geral, ossos da mão de tetanuros basais são pouco conhecidos, tendo em vista que comumente faltam falanges, carpais ou, até mesmo, a mão completa, limitando a informação. Os elementos de *Megaraptor* aqui estudados representam, portanto, importante material por fornecer novos dados morfológicos e, também, para o entendimento dos hábitos comportamentais.

Palavras-chave: *Megaraptor*. Theropoda. Formação Portezuelo. Cretáceo Superior. Patagônia.

INTRODUCTION

Recently, on the north coast of Barreales Lake in the Neuquén Province, at the Futalogno site, a complete manus (MUCPv-341) of the theropod *Megaraptor namunhuaiquii* Novas, 1998 was discovered (CALVO *et al.*, 2004a). In the present study we improve the description of some manus bones and analyse paleoecological aspects of this enigmatic dinosaur.

Phylogenetic relationships were previously established based on many different skeletal parts

of the theropod group taxa although some of the bones are rarely preserved, such as their hands. The anatomical study of the manus bones here developed allowed establishing a more accurate phylogenetic position of this species. Also, it is very profitable for comparative studies with other similar manual elements in other theropods (CALVO *et al.*, 2004a).

Several studies have been made focusing on diets and behaviors of the giant theropods (FARLOW & PIANKA, 2002). However, many of the results were based on the skull and teeth morphology, stomach contents,

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and coprolites. Anyway, there are several disparities of opinions concerning with these aspects. Although we recognize that it is very hard to interpret dinosaur diets with only postcranial elements, here we analyze the possible behavior of the giant cretaceous predator *Megaraptor namunhuaiquii*.

FOSSILS OF FUTALOGNKO SITE

The preserved forelimbs (MUCPv-341) of *Megaraptor namunhuaiquii* consist of a left scapula and coracoid, a right ulna and a radius, and a complete right manus. These materials were found associated to sauropods remains (CALVO *et al.*, 2001; CALVO, 2006), theropods (CALVO *et al.*, 2004b), ornithopods (PORFIRI & CALVO, 2002), fishes (GALLO *et al.*, 2003), plants (PRAMPARO *et al.*, 2003), turtles, crocodiles, and pterosaurs (KELLNER *et al.*, 2006).

MATERIAL AND METHODS

The material consists of a left scapula and coracoid, a right ulna and radius, and a complete right manus and it is housed in the Museo de Geología y Paleontología de la Universidad Nacional del Comahue under the number MUCPv-341.

It was examined with a PHILIPS TOMOSCAN MG helicoidal tomography, in sections of 1 to 2mm thickness with an overlapping of 50%. The two-dimensional images were saved in a DICOM (Digital Imaging and Communication in Medicine) standard format on the Philips system that provides mechanism for supporting the use of JPEG (Joint Photographic Expert Group) Image. The data was converted into three-dimensional images and saved as JPEG archives for visualization. The application of a computed tomography to the manus bones of *Megaraptor namunhuaiquii* demonstrates morphological data for a forelimb muscular insertion study (PORFIRI *et al.*, 2005). As a result, it was possible to obtain data on the surface of the bones, allowing the proposed study.

RESULTS

DESCRIPTION OF THE MATERIAL

The large theropod *Megaraptor* presents well

developed forelimbs. Digit I has a deep and wide sulcus on the ventral surface of phalanx I (Fig.1). This sulcus suggests the existence of a strong ligament uniting phalanx I (18.4cm long) with flexor tuberculum of ungual phalanx I (42cm long). Moreover, the enlarged laminar olecranon process of the ulna in *M. namunhuaiquii* indicates the insertion of a massive triceps (Fig.2). This muscle would give a higher force to *Megaraptor* hand during extensional movements. The triceps and flexor ligament would be efficient in seizing prey (Fig.3). Unfortunately, the humerus of *Megaraptor* was not preserved; however, the scapula and the coracoid preserved are morphologically similar to those of *Baryonyx* Charig & Milner, 1986. So, it is probably that the humerus had a similar robustness.

The acromial process of the scapula is oriented 90° with respect to the scapular blade and it is united one to another by a thin lamina. The distal end of the scapular lamina is compressed laterally. It is possible to observe a thin lamina on the posteroventral region. Approximately 1/3 of the distal end of the scapula is not preserved. So, it is not possible to know if there is a distal expansion similar to other theropods as *Allosaurus* Marsh, 1877 (MADSEN, 1976). The glenoid cavity is convex and formed by the articular facet for humerus. In anterior view, the scapula articulation with the coracoid has a semicircular shape in the ventral part. It expands dorsally in a thin lamina. The articulation is oriented perpendicular to the scapular lamina presenting an expansion on the ventral zone with respect to the dorsal one.

Metacarpals are articulated on the proximal region. Metacarpal I has asymmetrical distal condyles separated by a shallow sulcus. This asymmetry allowed a lateromedial rotation of digit I during the flexion movement (CALVO *et al.*, 2004a). Metacarpal II occupies almost 50 % of the dorsal surface of the carpals. Metacarpal III and their phalanges are flattened and deformed by postdepositional compression. This digit is more gracile than digits I or II. Concerning *Megaraptor* hand, one of the most important features is the presence of a metacarpal IV, which represents more than 1/3 of the total length of metacarpal III. This metacarpal is present in many primitive theropods. It is possible that metacarpal IV did not have mobility since it is fused to Metacarpal III and that it was almost imperceptible on the *M. namunhuaiquii* manus.

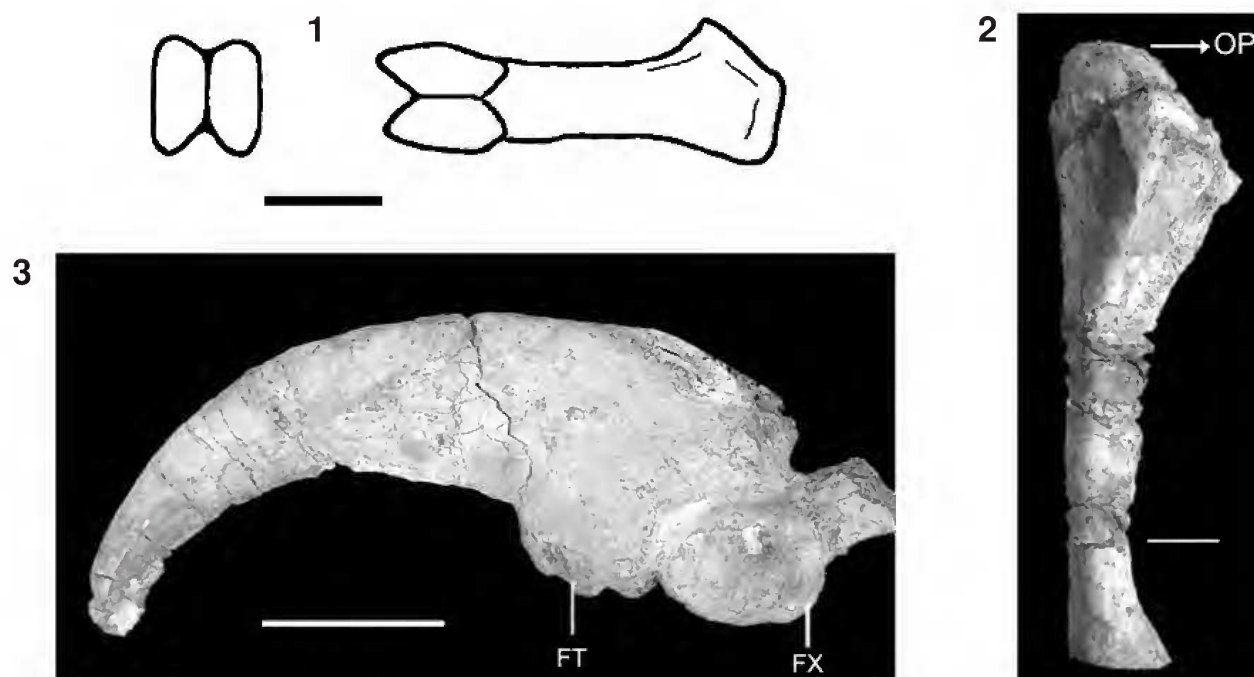


Fig.1- Phalanx I of the digit I in distal and ventral views. Scale bar = 5cm; fig.2 - ulna in lateral view. Abbreviation: (OP) olecranon process. Scale bar = 3cm; fig.3 - claw I of the digit I of *Megaraptor* in medial view. Abbreviations: (FT) flexor tubercle, (FX) phalanx I. Scale bar = 6cm.

DISCUSSION AND CONCLUSION

One important feature of *Megaraptor* is the presence of a sharp ventral border on its unguis phalanx of the digit I, finger I, indicating efficient raptorial abilities (Fig.4). This character is absent in other theropods in which the ventral border is rounded (Fig.5). The phalanx of digit I has a wide dorsal surface, strong enough to support a massive extensor muscle. The phalanges of digit II have smaller dorsal surfaces than those of the digits I and III. It suggests that the movement during hyperextension of the unguis phalanx was very strong, a condition needed to animals with raptorial habits. A claw with a sharp ventral surface is also present in dromaeosaurids (OSTROM, 1969; NOVAS & POL, 2005) as *Deinonychus* Ostrom, 1969 and *Neuquenraptor* Novas & Pol, 2005. This characteristic is only observable in the claw II of the pes of these animals since the other claws have flat ventral surfaces. *Deinonychus* hand has claws with rounded ventral surfaces as in *Allosaurus* (MADSEN, 1976). Therefore, the main tool for attack in *Deinonychus* was the claw II on the foot and the manus were used just for sustainability. The other claws of the foot would

have only a support utility. Due to the shape observed in the ventral border of *Megaraptor* manus, we deduce that the claw of phalanx I had the same function to that observed in *Deinonychus* and the claws II and III could also be related with the body support. Also, based on the fact that *Deinonychus* and *Neuquenraptor* were hunters and that it was possible to associate similarities between the ventral border of the foot claw II of these dromaeosaurids and the hand claw I of *Megaraptor*, it is here supposed that this giant predator of Patagonia had a hunter habit (Fig.6).

The radio rescued for the carcharodontosaurid *Mapusaurus roseae* (Coria & Currie, 2006) showed that its hands are larger, different from those observed in other large theropods as tyrannosaurids and abelisaurids (CORIA & CURRIE, 2006). The interpretation given by those authors to the metacarpals considering them as metacarpals II and III in *Mapusaurus* (MCF-PVPH-108.48) may be similar to that given to the metacarpals I and II of *Megaraptor* due to their similarity. As manual elements rescued in *Megaraptor* have close similarities to the carcharodontosaurid *Mapusaurus* it is possible to consider both having similar cranial

morphology, which may indicate that *Megaraptor* used the skull as main weapon and the forelimbs only for opening carcasses. Also, considering hands' morphology, both *Megaraptor* and *Baryonyx* (CHARIG & MILNER, 1997) are basal tetanurans that have similar ones. KITCHENER (1987) proposed that the spinosaurid *Baryonyx* could have been a carnivorous animal considering that their claws could have been utilized for opening dead bodies. Otherwise, *Baryonyx* was also interpreted as a piscivorous dinosaur (RAYFIELD & MILNER, 2005) based not only on the enormous claws, but also on the skull morphology, the tooth shape, and the stomach contents (*sensu* FARLOW & HOLTZ, 2002). However, evidence about *Megaraptor* dietary habits can only be related to its hand morphology since there

are no cranial materials to be studied. The teeth described by CALVO *et al.* (2004a) are not associated with cranial materials and, for this reason, were not considered in the present study. So that there are not enough data to support that *Megaraptor* had scavenger piscivorous habits.

Furthermore, based on related materials of more than one individual of *Megaraptor* from Barreales Lake, it is possible to indicate a social behavior for the genus (PORFIRI *et al.*, 2007) which is observed in other basal tetanurans, such as in *Mapusaurus* (CORIA & CURRIE, 2006). For this reason, it is possible that *Megaraptor* was an animal with group hunting habits, behavior observed in some living animal as lions and hyenas (FARLOW, 1976).

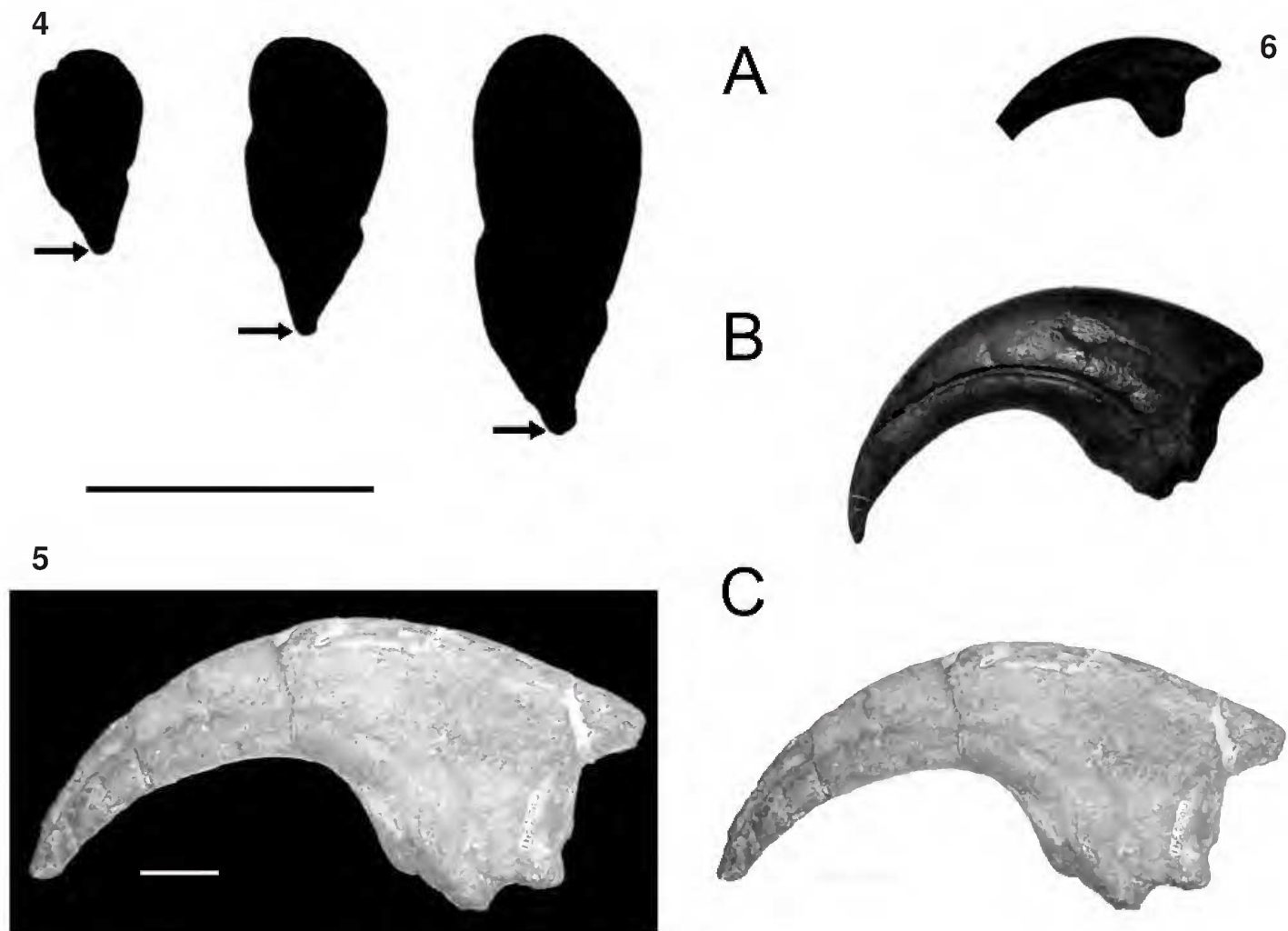


Fig.4 - Cut of the *Megaraptor*'s claw I of the digit I. The arrows show the cutting surface. Scale bar = 3cm; fig.5 - Claw II of the digit II. Scale bar = 2.5cm; fig. 6 - (A) pedal claw II of digit II in the dromaeosaurid *Neuquenraptor*; (B) unguis attributed to left manual digit I in the spinosaurid *Baryonyx*; (C) manual unguis in the Tetanurae *Megaraptor*. Only comparative, without scale.

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